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Michel A. Paul
DRDC Toronto

Gary W. Gray
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USAF AFRL
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Principal Author

Original signed by Michel Paul

Michel A. Paul, MSc

Approved by

Dr. Pang Shek

Head, Operational Medicine Section

Approved for release by

K. M. Sutton

Chair, Document Review and Library Committee

Abstract

Introduction. Based on previous work done at DRDC Toronto, the Aerospace and Undersea Medical Board drafted aeromedical policy to allow short term (maximum 5 days consecutive) flight surgeon supervised use of certain sleeping medications in aircrew during operations that are known to impact on aircrew sleep. Because of alternating day, off-circadian operations, there was a recent locally initiated change in the use of zopiclone in Camp Mirage aircrew to alternate day use throughout the 56-day rotations. DRDC Toronto was asked to evaluate this off-nominal use of zopiclone in CF aircrew. **Methods**. FAST^{TM} (Fatigue Avoidance Scheduling Tool) a performance modeling program was used to predict the impact of zopiclone and to compare an alternative duty schedule (3 days of work followed by three days off) against the current schedule (cycles one 1 day of work and 1 day off) across three mission take-off times (0300 hrs, 0700 hrs, and alternating 0700 hrs & 0300 hrs). Crew duty data and sleep behaviours (reported to the attending Flight Surgeon) were used as inputs to FAST^{TM} in order to generate 12 cognitive effectiveness models. **Results.** The models predict that the current schedule provides better sustained performance than a 3 days on/3 days off schedule, especially for the 0300 hrs take-off missions. The current use of zopiclone to support early circadian pre-mission sleep predicts a 4% to 6% increase in average mission cognitive effectiveness relative to no use of zopiclone. **Discussion.** These performance models were based on reported sleep behaviours as distinct from actgraphically measured sleep. This modelling effort, although worthwhile in the short term, should be repeated based on actigraph data in order to provide objective sleep behaviour for re-calculating the performance models.

Résumé

Introduction. À la lumière des travaux antérieurs de RDDC Toronto, la Commission de médecine aérospatiale et sous-marine a préparé une ébauche de politique aéromédicale autorisant l'utilisation à court terme (jusqu'à un maximum de 5 jours consécutifs), sous la supervision d'un médecin de l'air, de certains somnifères par des membres d'équipages pendant les missions qui sont de nature à perturber le sommeil. En raison des opérations ayant lieu tous les deux jours et ne respectant pas le rythme circadien, on a récemment modifié l'utilisation faite de la zopiclone par les membres d'équipages du Camp Mirage, de sorte qu'ils en prennent maintenant tous les deux jours pour la durée entière de la rotation (56 jours). RDDC Toronto a été chargée d'évaluer cette utilisation atypique de la zopiclone chez les équipages des FC. **Méthode**. Le logiciel FAST^{TM} (Fatigue Avoidance Scheduling Tool – outil d'établissement d'horaires visant à éviter la fatigue), qui est un programme de modélisation du rendement, a été utilisé pour prédire l'effet de la nouvelle utilisation de la zopiclone et pour comparer un horaire de travail de remplacement (alternance de 3 jours de travail et de 3 jours de congé) et l'horaire actuellement utilisé (alternance des jours de travail et de congé) pour chacun des trois horaires de départ des missions (3 h, 7 h, alternance de 7 h et de 3 h). Les données sur les tâches et sur les habitudes de sommeil des membres d'équipages (transmises au médecin de l'air responsable) ont été entrées dans le logiciel FAST^{TM} afin de générer 12 modèles d'efficacité cognitive. **Résultats.** D'après les modèles, l'horaire actuellement utilisé produit un rendement soutenu supérieur à celui obtenu avec l'alternance de 3 jours de travail et de 3 jours de congé, surtout pour les missions dont le départ est à 3 h. L'utilisation actuelle de la zopiclone pour faciliter l'induction anticipée du sommeil circadien avant les missions entraîne une augmentation de 4 à 6 % de l'efficacité cognitive pendant les missions. **Discussion.** Les présents modèles de rendement étaient fondés sur les cycles de sommeil observés et non sur des enregistrements actigraphiques du sommeil. Cette modélisation même si elle est valable à court terme, doit être répétée à l'aide des données actigraphiques obtenues afin de produire des données objectives sur le sommeil qui serviront à recalculer les modèles de rendement.

Executive summary

Preliminary assessment of zopiclone (Imovane^{TM}) use in Camp Mirage Aircrew

Paul, M.A., Gray, G.W., Miller, J.C.; DRDC Toronto TR 2006-077; Defence R&D Canada – Toronto; May 2006.

Background

Based on previous work done at DRDC Toronto, the Aerospace and Undersea Medical Board drafted aeromedical policy to allow short term (maximum 5 days consecutive) flight surgeon supervised use of certain sleeping medications in aircrew during missions that are known to impact on aircrew sleep. Because of alternate day, off-circadian operations, there was a recent locally-initiated change in the use of zopiclone in Camp Mirage aircrew to alternate day use throughout the 56-day rotation. DRDC Toronto was asked to evaluate this off-nominal use of zopiclone. FAST^{TM} (Fatigue Avoidance Scheduling Tool), a performance modeling program, was used to predict the impact of this use of zopiclone and to compare an alternative duty schedule (3 days of work followed by three days off) against the current schedule (cycles one 1 day of work and 1 day off) across three mission take-off times (0300 hrs, 0700 hrs, and alternating 0700 hrs & 0300 hrs).

Results

The models predict that the current schedule provides better sustained performance than the alternative schedule, especially for the 0300 hrs take-off missions. The current use of Imovane to support early circadian pre-mission sleep predicts a 4% to 6% increase in average mission cognitive effectiveness relative to no use of zopiclone.

Significance

These performance models were based on reported sleep behaviours as distinct from the usual scientifically measured sleep. This current effort is worthwhile in the short term in that it provides a preliminary assessment of the impact of an alternative schedule and the modified use of zopiclone in Canadian Forces Transport Aircrews. However, this work should be repeated by using scientifically measured aircrew sleep in order to provide objective sleep data for re-calculating the performance models.

Future plans

Camp Mirage aircrew should be asked to participate in an accurate evaluation of their sleep with zopiclone by wearing wrist actigraphs (a watch-like device) which can quantify daily sleep to the nearest minute.

Sommaire

Preliminary assessment of zopiclone (Imovane^{TM}) use in Camp Mirage Aircrew

Paul, M.A., Gray, G.W., Miller, J.C.; DRDC Toronto TR 2006-077; R & D pour la défense Canada – Toronto; May 2006.

Introduction et renseignements généraux

À la lumière des travaux antérieurs de RDDC Toronto, la Commission de médecine aérospatiale et sous-marine a préparé une ébauche de politique aéromédicale autorisant l'utilisation à court terme (jusqu'à un maximum de 5 jours consécutifs), sous la supervision d'un médecin de l'air, de certains somnifères par les membres d'équipages pendant les missions qui sont de nature à perturber le sommeil. En raison des opérations ayant lieu tous les deux jours et ne respectant pas le rythme circadien, on a récemment modifié l'utilisation faite de la zopiclone par les membres d'équipages du Camp Mirage, de sorte qu'ils en prennent maintenant tous les deux jours pour la durée entière de la rotation (56 jours). RDDC Toronto a été chargée d'évaluer cette utilisation atypique de la zopiclone. Le logiciel FAST^{TM} (Fatigue Avoidance Scheduling Tool – outil d'établissement d'horaires visant à éviter la fatigue), qui est un programme de modélisation du rendement, a été utilisé pour prédire l'effet de la nouvelle utilisation de la zopiclone et pour comparer un horaire de travail de remplacement (alternance de 3 jours de travail et de 3 jours de congé) et l'horaire actuellement utilisé (alternance des jours de travail et de congé) pour chacun des trois horaires de départ des missions (3 h, 7 h, alternance de 7 h et de 3 h).

Résultats

D'après les modèles, l'horaire actuellement utilisé produit un rendement soutenu supérieur à celui obtenu avec l'horaire de remplacement, surtout pour les missions dont le départ est à 3 h. L'utilisation actuelle d'Imovane^{TM} pour faciliter l'induction anticipée du sommeil circadien avant les missions entraîne une augmentation de 4 à 6 % de l'efficacité cognitive pendant les missions.

Signification

Contrairement à l'habitude, les présents modèles de rendement étaient fondés sur les cycles de sommeil observés et non sur des enregistrements scientifiques du sommeil. Cette modélisation est valable à court terme, puisqu'elle donne une première idée de l'effet d'un horaire différent et de la nouvelle utilisation de la zopiclone chez les équipages d'aéronefs de transport des FC. Par contre, elle doit être répétée à l'aide de données scientifiques sur le sommeil des membres d'équipages afin de produire des données objectives sur le sommeil qui serviront à recalculer les modèles de rendement.

Plans d’avenir

Il faut inviter les membres d’équipages du Camp Mirage à participer à une évaluation exacte de leur sommeil induit par la zopiclone en leur demandant de porter au poignet un actigraphe (appareil semblable à une montre), qui peut mesurer le sommeil quotidien à la minute près.

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Acknowledgements

The authors hereby acknowledge the helpful input of Lt(N) Lee Simpson vis-à-vis 1) estimations of Camp Mirage aircrew sleep behaviour and the 2) provision of the Tactical Airlift Operational Schedule both of which allowed us to model aircrew cognitive effectiveness with the FAST (Fatigue Avoidance Scheduling Tool) modelling software.

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1. Background/problem definition

Based on previous work done at DRDC Toronto (1-6) the Aerospace and Undersea Medical Board (AUMB) drafted aeromedical policy recommendations for the short term maximum 5 days consecutive flight surgeon-supervised use of the sleeping medications zopiclone (marketed as Imovane™) and zaleplon (marketed as Starnoc™).

More recently zopiclone has been used in Camp Mirage aircrew on an alternating day basis in support of the early circadian sleep that is dictated by either night-time or early morning operations. This recent alternating day use of zopiclone has resulted in concern among Canadian Forces aeromedical physicians. It is in this context that DRDC Toronto was asked to conduct a preliminary evaluation of this alternating daily use of zopiclone in our air transport aircrews conducting TAL (Tactical Airlift) Operations from Camp Mirage.

2. FAST™ Analysis of Camp Mirage CC130 TAL Operations

2.1 Fast™ Modelling Program

A description of the FAST^{TM} (Fatigue Avoidance Scheduling Tool) is provided in Appendix D. FAST^{TM} graphs are shown in Appendix A for missions with 0300 hrs take-offs, Appendix B for missions with 0700 hrs take-offs and Appendix C missions with take-offs alternating between 0300 hrs and 0700 hrs. Some details regarding these graphs are as follows:

- The vertical axis on the left side of the FAST^{TM} graphs represents human performance effectiveness and is demonstrated by the oscillating line in the diagram representing group average performance (cognitive effectiveness) as determined by time of day, biological rhythms, time spent awake, and amount of sleep.
- The dotted line which is below the cognitive effective curve and follows a similar oscillating pattern as the cognitive effectiveness represents the 10th percentile of cognitive effectiveness.
- The green band represents acceptable performance effectiveness for workers conducting safety sensitive jobs (flying, driving, weapons operation, command and control, etc.).
- The yellow performance band (from 60% to 90% cognitive effectiveness) indicates caution. Personnel engaged in skilled performance activities such as aviation should not be functioning in this performance band.
- The area from the dotted line to the pink area represents cognitive effectiveness during the circadian nadir and during a 2nd day without sleep.
- The pink performance band (below 65%) represents performance effectiveness after 2 days and a night of sleep deprivation. Under these conditions, no one can be expected to function well on any task.
- The vertical axis on the right side of FAST™ graphs represents the Blood Alcohol equivalence throughout the spectrum of cognitive effectiveness. A value of 77% cognitive effectiveness corresponds to a blood alcohol level of 0.05%.
- The abscissa illustrates periods of work (red bars), sleep (blue bars), darkness (gray bars) and time of day in hours

2.2 Modelling methods

The models relate 3 factors (take-off time, duty schedule, and drug). The models assessed different take-off times (0300 hrs in Appendix A, 0700 hrs in Appendix B, and alternating 0300 hrs and 0700 hrs in Appendix C); 2 types of duty schedule (WOWOWO and WWWOOO where W = a working day and O = a day off) and 2 states of zopiclone (either no zopiclone or a zopiclone dose upon going to bed for the sleep immediately prior to a mission). These 3 levels of take-off x 2 levels of duty schedule x 2 levels of drug generate a matrix of 12 cognitive effectiveness models.

Of the two data sets which are used to generate FAST™ cognitive effectiveness models (sleep data and work schedule data), generally, the sleep data is collected with wrist activity monitors. However, the Camp Mirage Flight Surgeon provided estimations of the sleep behaviour of the aircrew she is supporting. These estimated aircrew sleep behaviours were used consistently throughout the models in the following manner.

Whether the models reflected a WOWOWO or a WWWOOO schedule, the daily sleep behaviour estimates were identical. For the 0300 hr take-off missions, subjects retired to bed at 1600 hrs and arose from bed at 2400 hrs, reporting to Operations at 0100 hrs for the 0300 hr take-off. Between 1600 hrs and 2400 hrs sleep was classified as fair when the crews were sleeping without Imovane™ and as excellent when they used Imovane™. For the 0700 hr take-off missions, subjects retired to bed at 2100 hrs and arose from bed at 0400 hrs, reporting to Operations at 0500 hrs for the 0700 hr take-off. Between 2100 hrs and 0400 hrs, sleep was classified as fair when the crews were sleeping without Imovane™ and as excellent when they used Imovane™. Sleep during days off occurred between 2300 hrs and 0700 hrs without Imovane™ and was rated as good.

2.3 Modelling results

The 4 models (WOWOWO without and with Imovane™, WWWOOO without and with Imovane™) for the 0300 hr take-offs are illustrated in Appendix A. The same 4 models which correspond to the 0700 hrs, and the alternating 0300 hr & 0700 hr take-offs are shown in Appendices B and C, respectively.

Table 1: Cognitive effectiveness as a function of schedule and use of Imovane™ to facilitate early circadian sleep pre-mission

Take-off times	Schedule	Imovane™ use pre-mission	Average % duty cognitive effectiveness	Average Imovane™ benefit (% cog effectiveness)
0300 hrs	WOWOWO	NO	81	
0300 hrs	WOWOWO	YES	85	4
0300 hrs	WWWOOO	NO	77*	
0300 hrs	WWWOOO	YES	82	5
0700 hrs	WOWOWO	NO	86	
0700 hrs	WOWOWO	YES	92	6
0700 hrs	WWWOOO	NO	86	
0700 hrs	WWWOOO	YES	92	6
Alt 0700 & 0300 hrs	WOWOWO	NO	86	
Alt 0700 & 0300 hrs	WOWOWO	YES	90	4
Alt 0700 & 0300 hrs	WWWOOO	NO	85	
Alt 0700 & 0300 hrs	WWWOOO	YES	90	5

* 77% cognitive effectiveness equates to a blood alcohol level of 0.05%

3. Discussion

During the currently used WOWOWO schedules without the use of zopiclone, the 0300 hrs take-offs provided mission cognitive effectiveness of 81% while each of the 0700 hrs and alternating 0700 hrs & 0300 hrs take-offs predict a mission cognitive effectiveness 5% higher (i.e., 86%). For the possible alternate WWWOOO schedules without the use of Imovane™, the 0300 hrs take-off predicts a mission cognitive effectiveness of 77% (an impairment equivalent to a blood alcohol level of 0.05%) while the predicted mission cognitive effectiveness for each of the 0700 hrs and alternating 0700 hrs & 0300 hrs take-offs remains at 86%. In this case, it can be argued that the cost of the 0300 hrs take-offs during a WWWOOO schedule is a mission cognitive effectiveness penalty of 9%. The sleep behaviour assumptions for improvement of sleep predict that mission cognitive effectiveness will improve by 4% to 6% depending on the mission take-off timings and the WOWOWO vs WWWOOO schedules (Table 1).

Since these results are based on sleep behaviour estimates provided by Camp Mirage aircrew in interviews with their attending Flight Surgeon, these results should not be taken as the final answers to questions with respect to any benefits of aircrew taking Imovane™ in the context of TAL Operations support to troops in Afghanistan. The current models demonstrate that the WOWOWO work schedule currently in use is significantly better than the WWWOOO alternative in the context of the 0300 hrs take-offs but makes no difference in either the 0700 hrs or the alternating 0700 hrs & 0300 hrs take-offs. In light of these findings, it could be argued that the current WOWOWO schedule should be retained since it does produce a significant benefit relative to the WWWOOO alternative during night operations. Further, since the WWWOOO schedule would allow the aircrew 3 consecutive days off every 3 days, the aircrew might slip into non-optimal sleep behaviour (due to what amounts to essentially a long weekend every 3 days) with an attendant fatigue-induced exacerbation of mission cognitive effectiveness. Based on our modelled assumptions for the sleep benefits of zopiclone, the models predict a modest 4% to 6% increase in mission cognitive effectiveness attributable to zopiclone across the matrix of models documented in Table 1.

It should be noted that the average cognitive performance effectiveness predictions for the missions seldom reached the minimum recommended level of 90%, even in the best-case scenarios (Table 1). Only the average cognitive effectiveness value for an entire mission value is reported here. However, visual inspection of the figures in Appendices A and C reveals that the 0300 hrs take-off missions tend to terminate during the mid-afternoon slump in cognitive performance, and that this slump may reach down to 80% effectiveness.

The risk of a fatigue-induced mishap will be quite high during many of the missions modeled here, especially during the termination approach and landing of the 0300 hrs missions. To counter this problem, the aircrews should assume that they will make fatigue-induced mistakes and take positive steps to protect themselves. For example, run every checklist twice, and get sleep whenever possible (i.e., use the "any sleep is good" philosophy).

The next step for quantification of any sleep benefits (and therefore mission cognitive effectiveness benefits) with zopiclone would be to quantify aircrew sleep via wrist activity and input those actigraphic sleep data into FAST™ along with the corresponding crew duty day data.

4. Recommendations

1. AUMB was briefed 18 April 06 on the results of this FAST™ analysis of Camp Mirage aircrew. The consensus AUMB recommendation was to approve the alternate day use of Imovane™ through the 56-day Camp Miarge rotation of CC130 aircrew, under careful supervision of the Camp Miarge Flight Surgeon, with the following constraints.

    a. Aircrew should receive a briefing on sleep hygiene including the voluntary use of Imovane™ before or shortly after arrival at Camp Mirage

    b. Imovane™ should be dispensed in 2-week quantities

    c. There should be a minimum 8-hour window between Imovane™ ingestion and report for duty.

2. The AUMB briefed the Aeromedical Policy & Standards Committee (APSC) 19 April 06. The recommendations were supported by APSC.

3. It is recommended that more objective data on sleep patterns in Camp Mirage aircrew be obtained using wrist actigraphs. This could include a more formal scientifically designed study to assess the efficacy of Imovane™ (or other hypnotic) through the Camp Mirage aircrew rotations.

References

[1] Paul MA, Brown G, Buguet A, Gray G, Pigeau RA, Weinberg H, Radomski M. Melatonin and Zopiclone as Pharmacologic Aids to Facilitate Crew Rest. Aviat Space Environ Med 2002, 72 (11): 974-84.

[2] Paul MA, Gray G, Kenny G, Pigeau R. Impact of Melatonin, Zaleplon, Zopiclone, and Temazepam on Psychomotor Performance. Aviat Space Environ Med 2003; 74 (12): 1263-70.

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[4] Paul MA, Gray G, Sardana TM, Pigeau RA. Melatonin and Zopiclone as Facilitators of Early Circadian Sleep in Operational Air Transport Crews. Aviat Space Environ Med 2004; 75 (5): 439-43.

[5] Paul MA, Gray GW, Sardana TM, Pigeau RA. Fatigue Countermeasures In Support Of CF CC130 Air Transport Operations: from the operation to the laboratory and back to the operation. 2003, Defence Research and Development Canada--Toronto, 2003; Report No. TR 2003-106.

[6] Paul MA, Pigeau RA, Weinberg H. CC130 Pilot Fatigue during Re-supply Missions to Former Yugoslavia. Aviat Space Environ Med 2001; 72 (11): 965-73.

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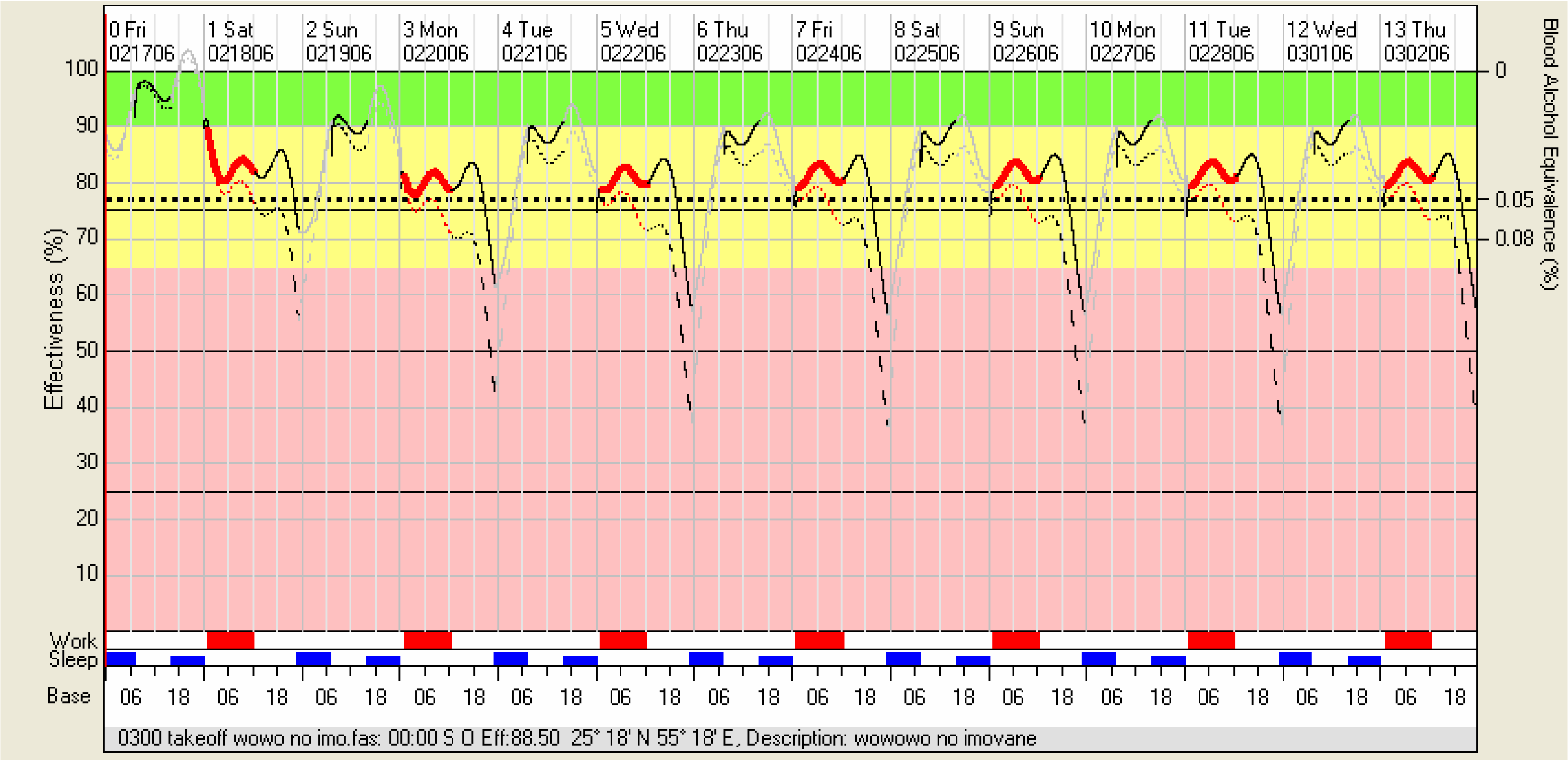
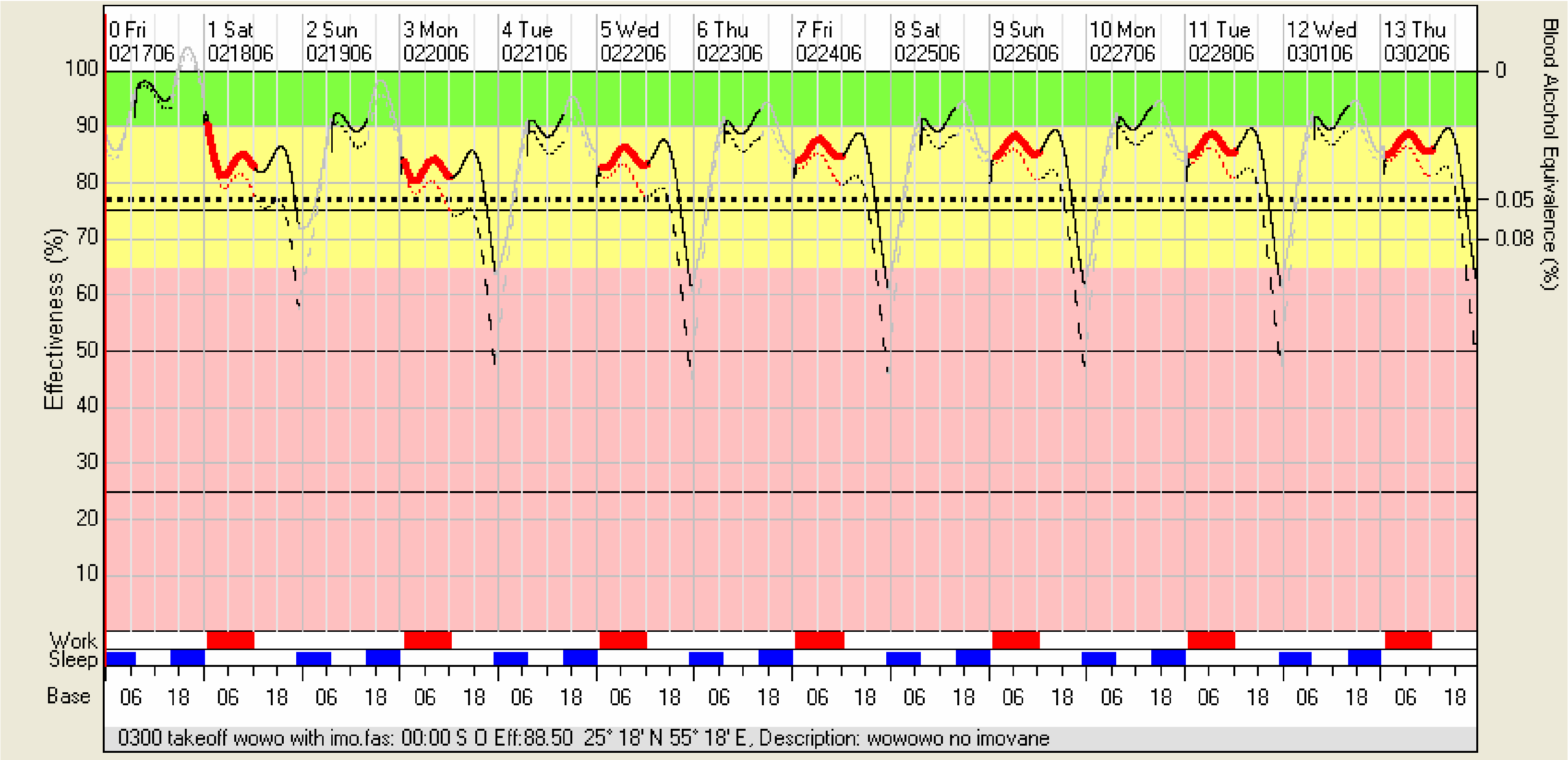
Annex A Fast™ Graphs for 0300 hr take-offs

0300 hrs take-off, WOWOWO schedule with no use of Imovane™



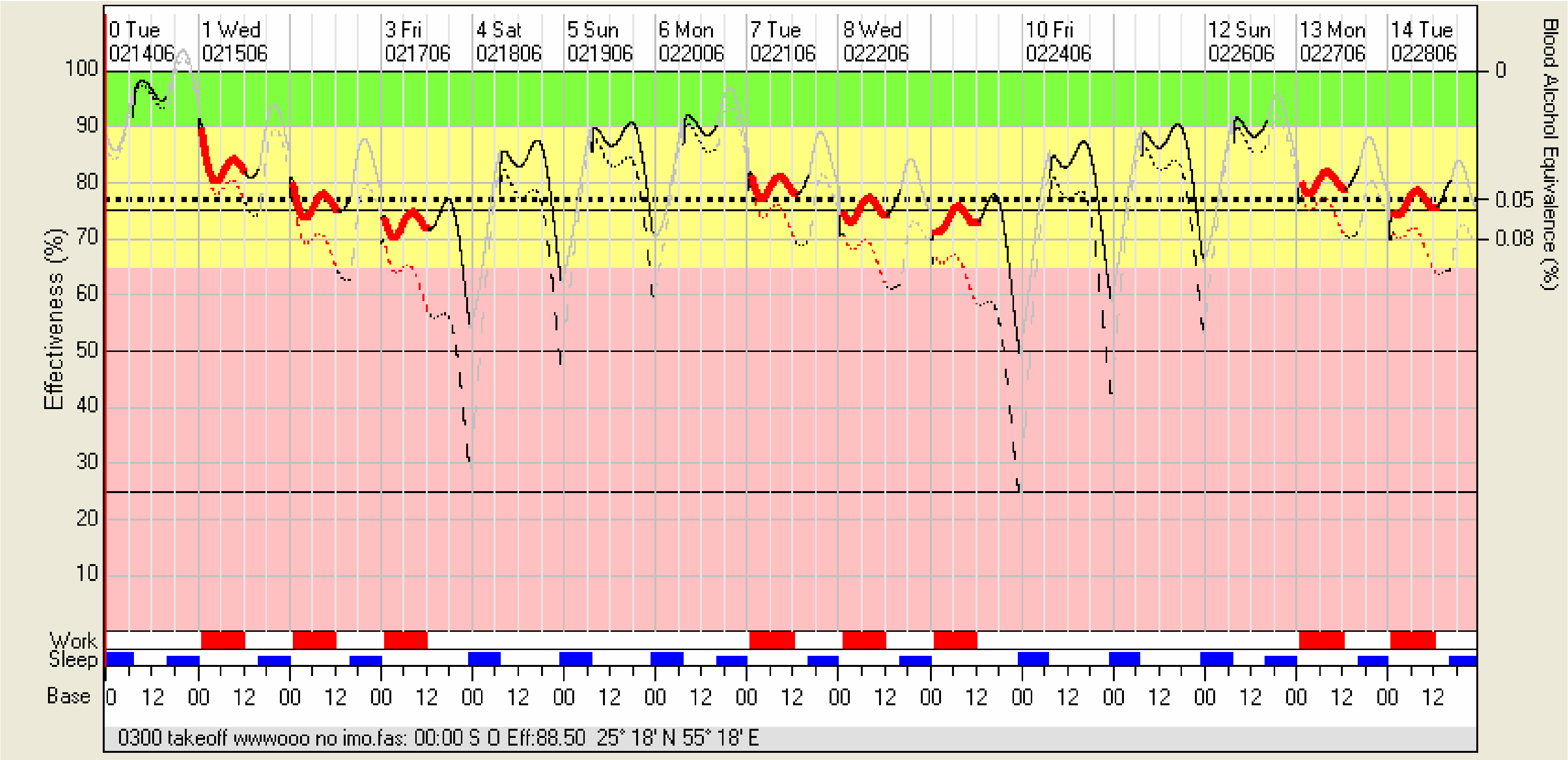
Average mission cognitive effectiveness is 81%

0300 hrs take-off, WOWOWO schedule with pre-mission sleep on Imovane™



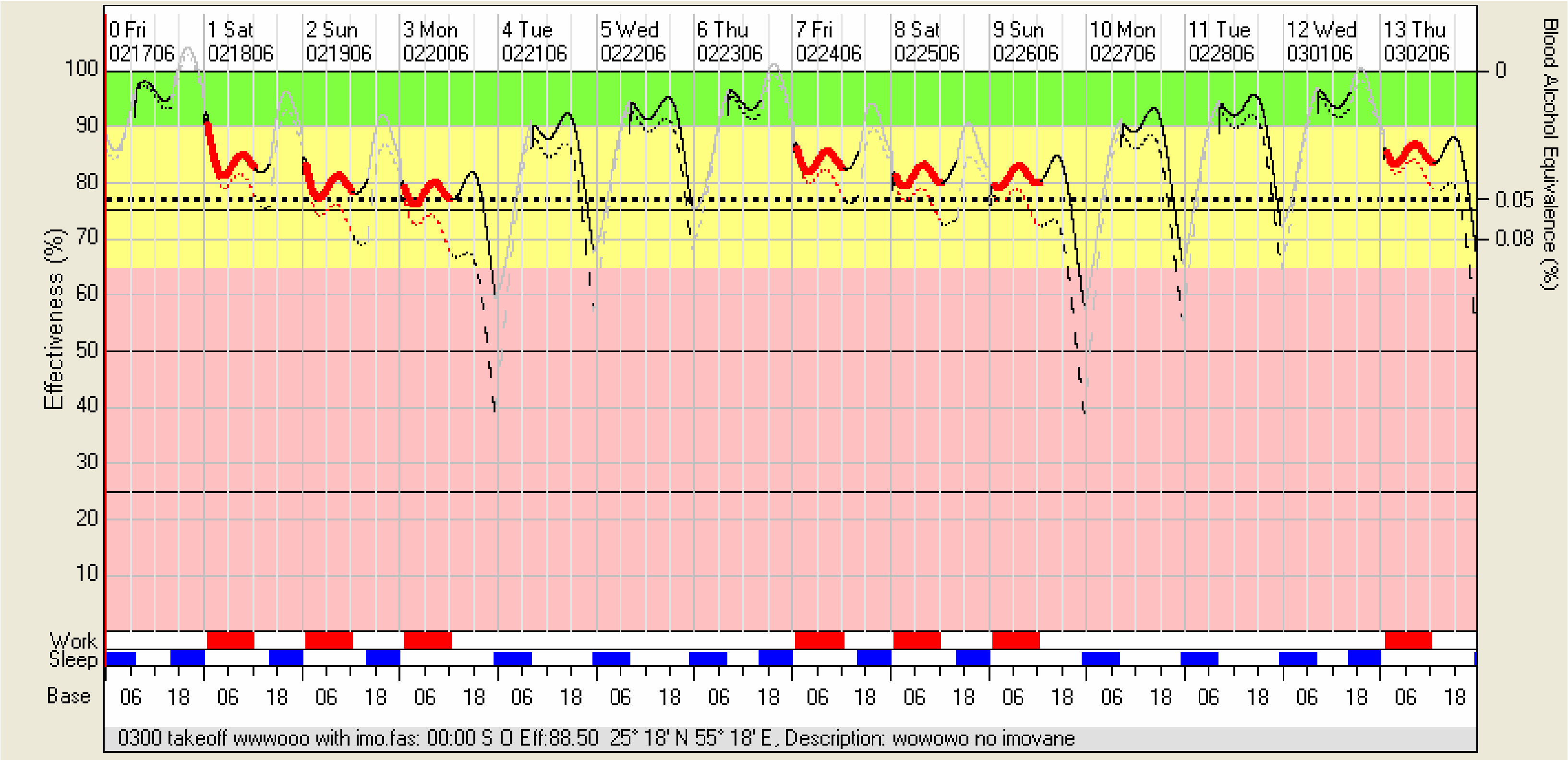
Average mission cognitive effectiveness is 85%

0300 hrs take-off, WWWOOO schedule with no use of Imovane™



Average mission cognitive effectiveness is 77% (an impairment equivalent to a blood alcohol level of 0.05%)

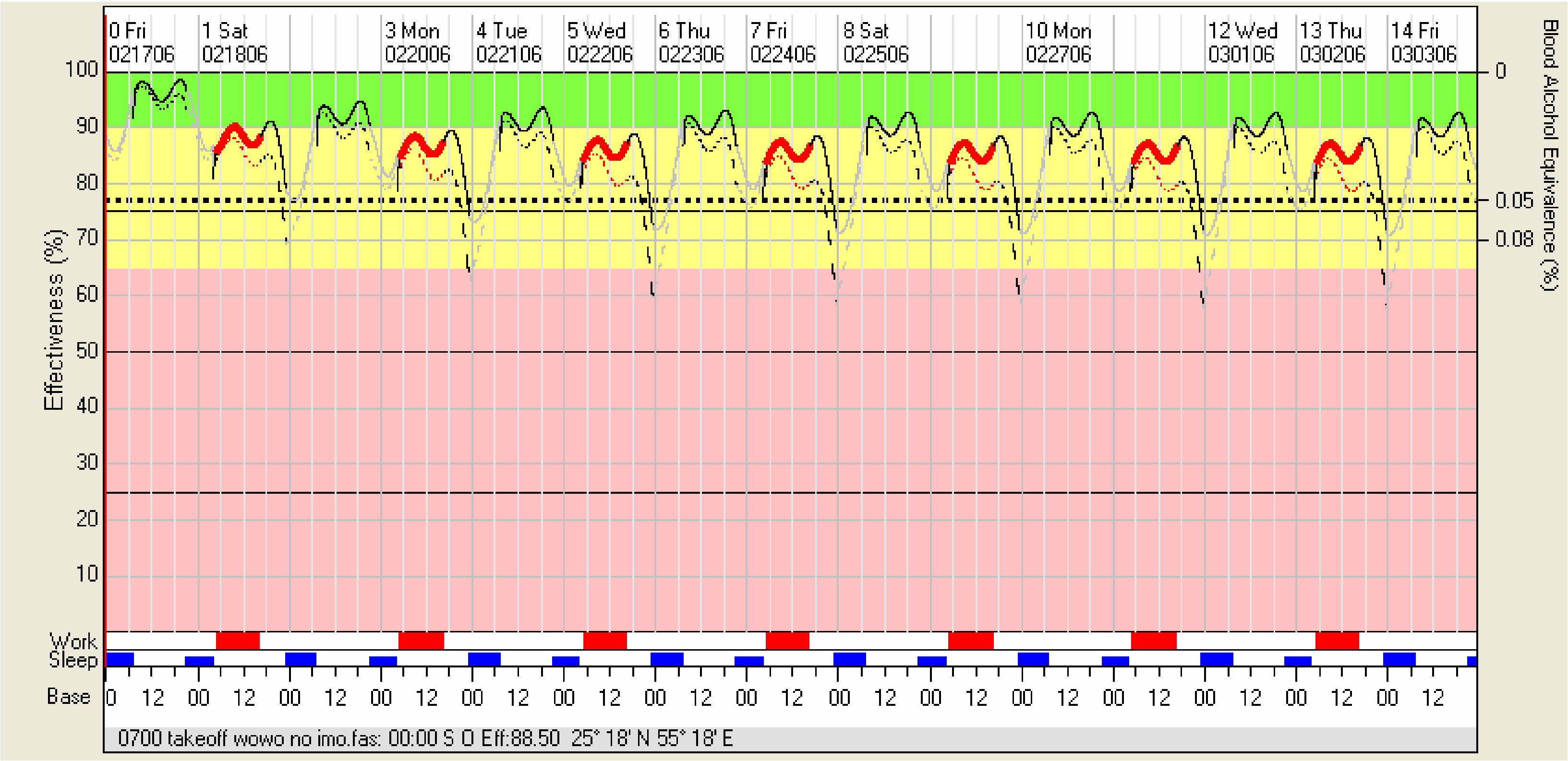
0300 hrs take-off, WWWOOO schedule with pre-mission sleep on Imovane™



Average mission cognitive effectiveness is 82%

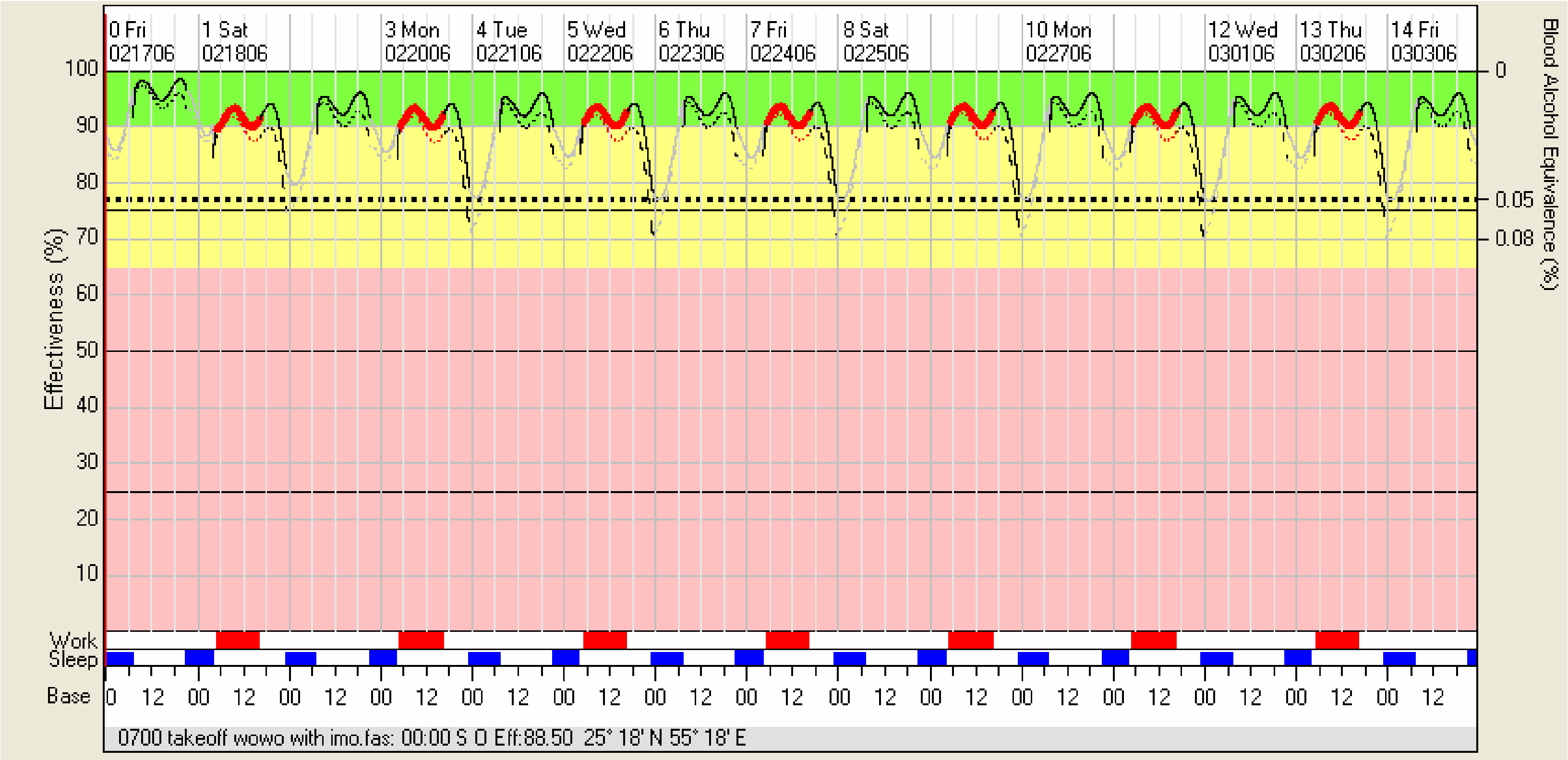
Annex B   Fast™ Graphs for 0700 hr take-off

0700 hrs take-off, WOWOWO schedule with no use of Imovane™



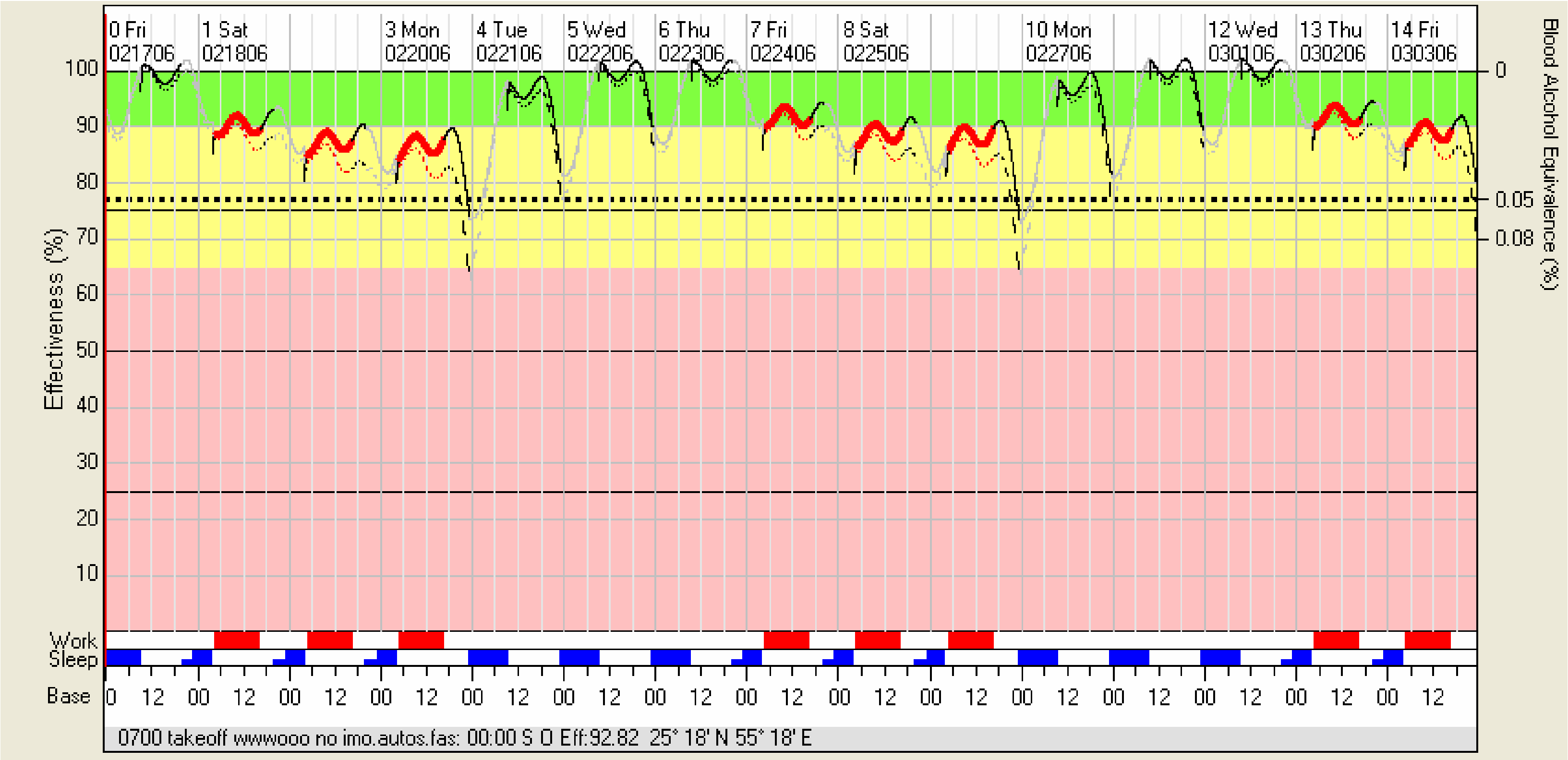
Average mission cognitive effectiveness is 86%

0700 hrs take-off, WOWOWO schedule with pre-mission sleep on ImovaneTM



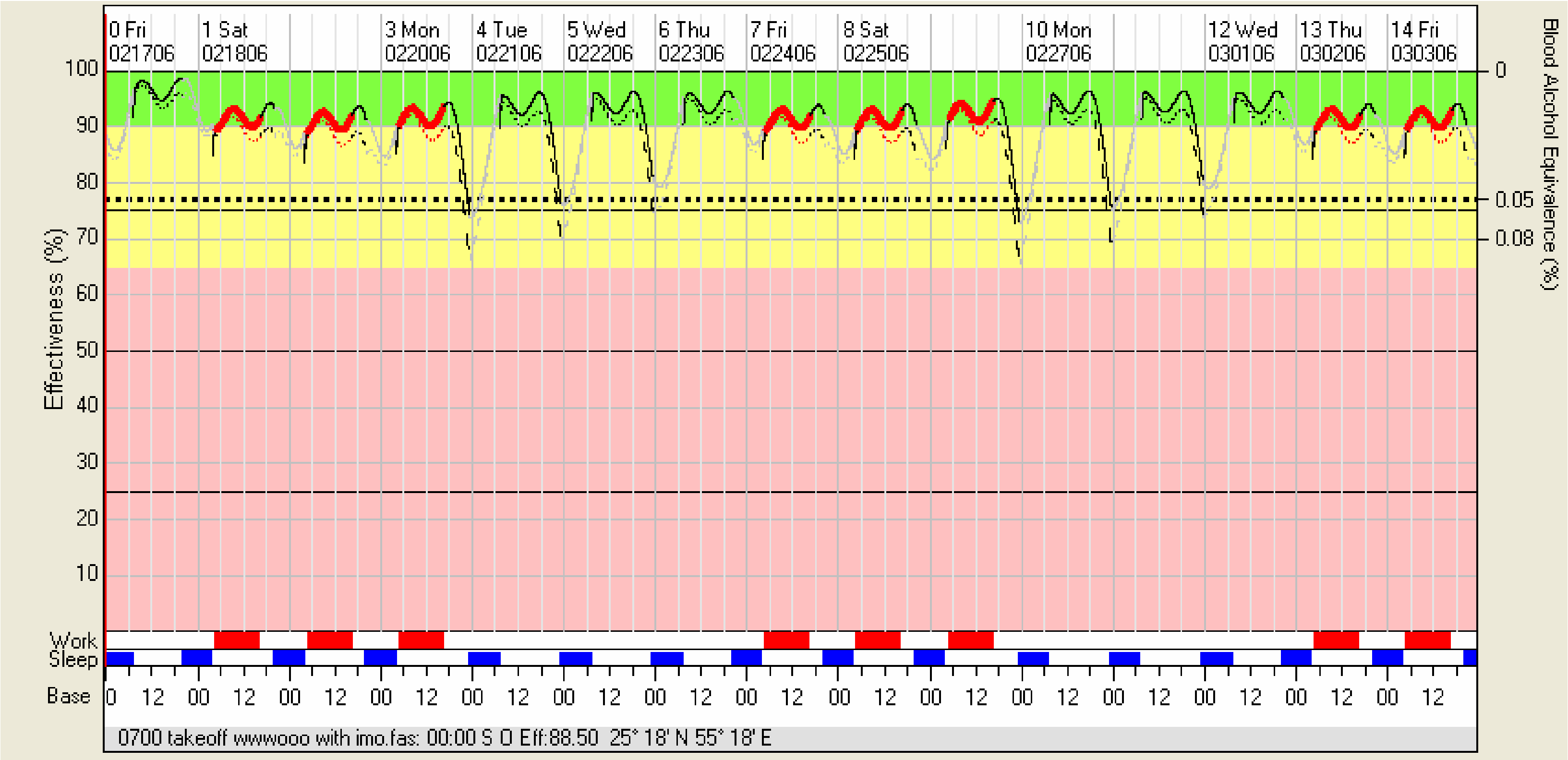
Average mission cognitive effectiveness is 92%

0700 hrs take-off, WWWOOO schedule with no use of Imovane™



Average mission cognitive effectiveness is 86%

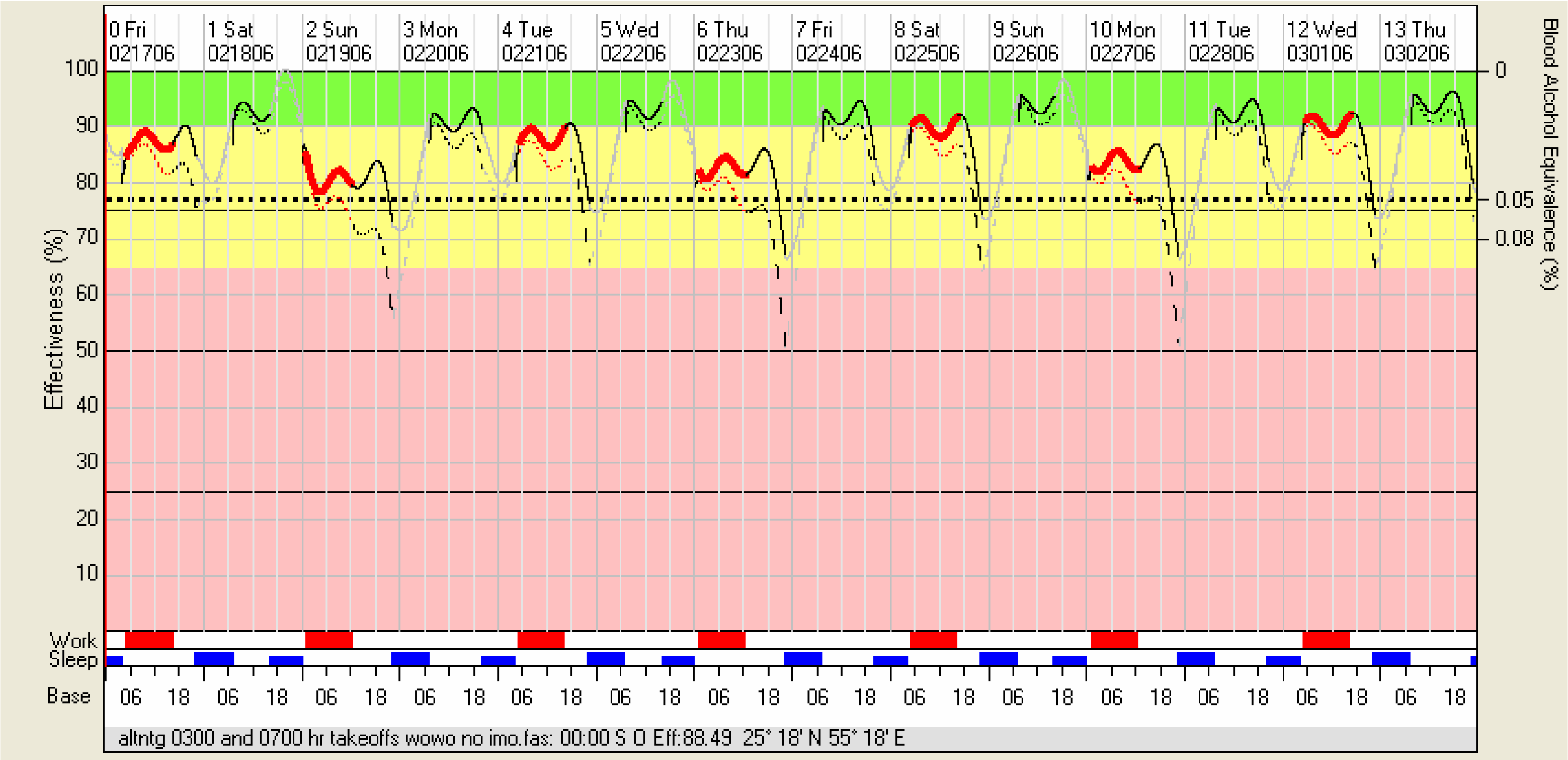
0700 hrs take-off, WWWOOO schedule with pre-mission sleep on Imovane™



Average mission cognitive effectiveness is 92%

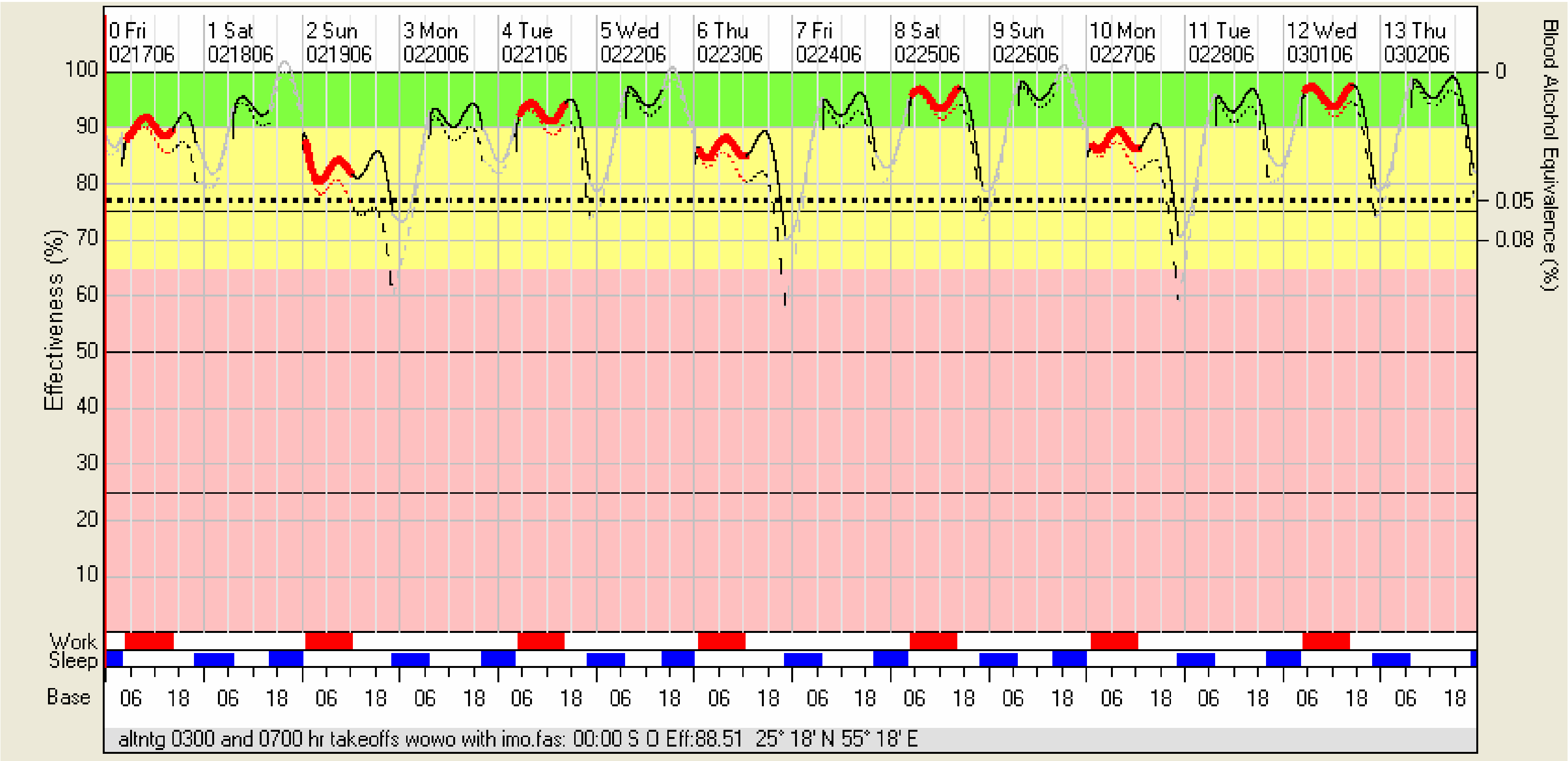
Annex C Fast™ Graphs for alternating 0700 hrs & 0300 hrs take-off

Alternating 0700 hrs & 0300 hrs take-off, WOWOWO schedule with no use of Imovane™



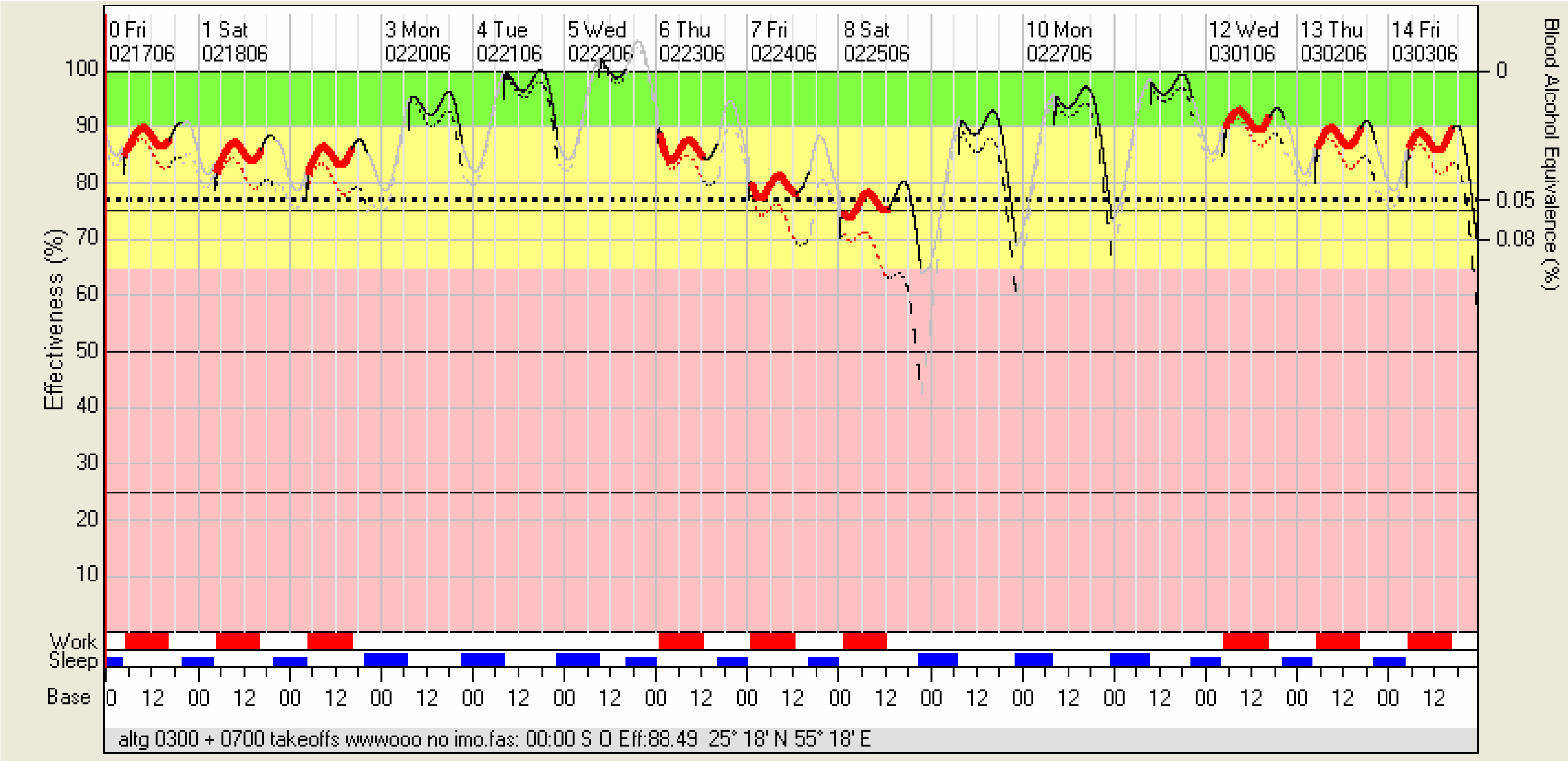
Average mission cognitive effectiveness is 86%

Alternating 0700 hrs & 0300 hrs take-off, WOWOWO schedule with pre-mission sleep on Imovane™



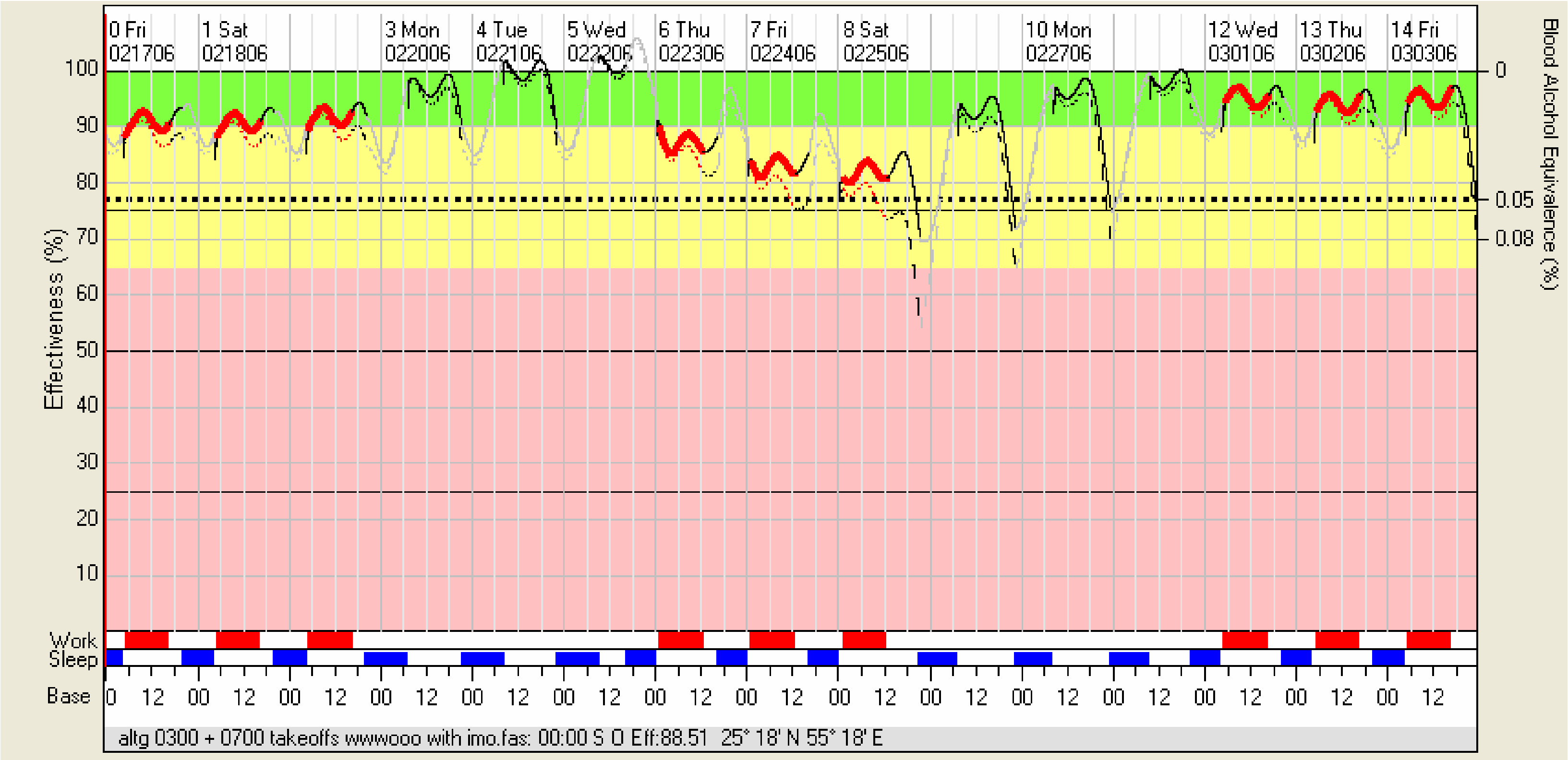
Average mission cognitive effectiveness is 92%

Alternating 0700 hrs & 0300 hrs take-off, WWWOOO schedule with no use of Imovane™



Average mission cognitive effectiveness is 85%

Alternating 0700 hrs & 0300 hrs take-off, WWWOOO schedule with pre-mission sleep on Imovane™



Average mission cognitive effectiveness is 90%

Annex D Sleep, Activity, Fatigue and Task Effectiveness (SAFTE) Model

D.1 Fatigue Avoidance Scheduling Tool (*FAST*™)

The Sleep, Activity, Fatigue and Task Effectiveness (SAFTE) model integrates quantitative information about (1) circadian rhythms in metabolic rate, (2) cognitive performance recovery rates associated with sleep, and cognitive performance decay rates associated with wakefulness, and (3) cognitive performance effects associated with sleep inertia to produce a 3-process model of human cognitive effectiveness.

The SAFTE model has been under development by Dr. Steven Hursh for more than a decade. Dr. Hursh, formerly a research scientist with the US Army, is employed by SAIC (Science Applications International Corporation) and Johns Hopkins University and is currently under contract to the WFC (Warfighter Fatigue Countermeasures) R&D Group and NTI, Inc. to modify and expand the model.

The general architecture of the SAFTE model is shown in Figure 1. A circadian process influences both cognitive effectiveness and sleep regulation. Sleep regulation is dependent upon hours of sleep, hours of wakefulness, current sleep debt, the circadian process and sleep fragmentation (awakenings during a sleep period). Cognitive effectiveness is dependent upon the current balance of the sleep regulation process, the circadian process, and sleep inertia.

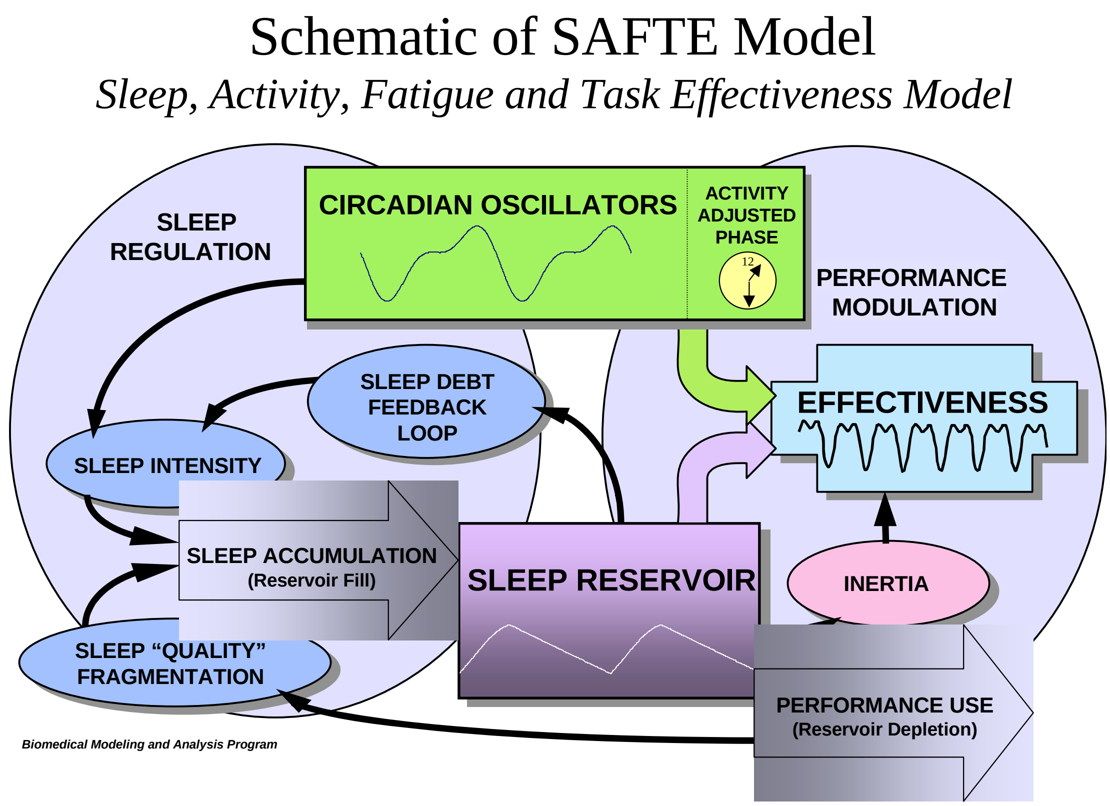


Figure 1. Schematic of SAFTE Model

SAFTE has been validated against group mean data from a Canadian laboratory that were not used in the model’s development (Hursh et al., in review). Additional laboratory and field validation studies are underway and the model has begun the USAF Verification, Validation and Accreditation (VV&A) process.

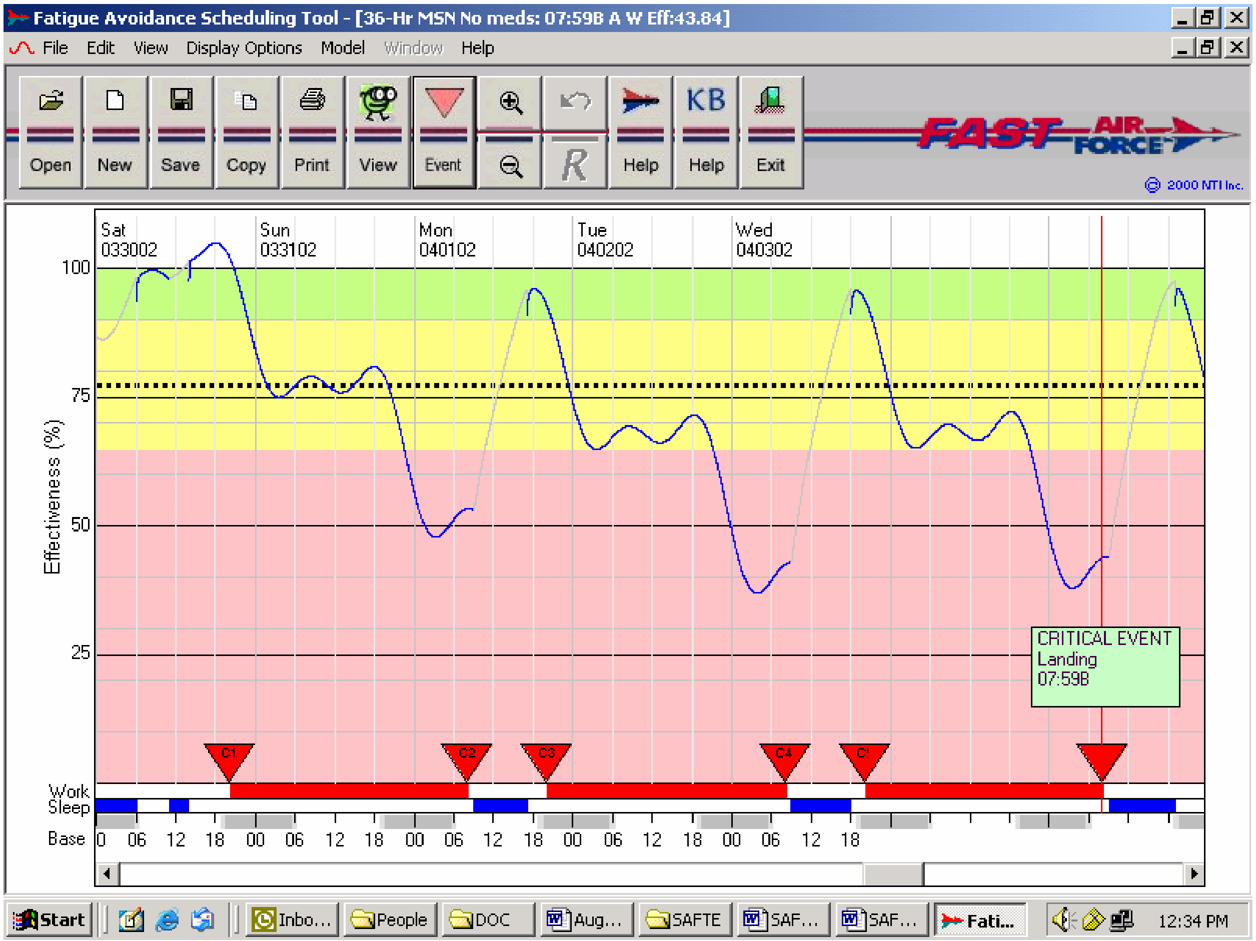
The model does not incorporate the effects of pharmacological alertness aids; chronic fatigue (motivational exhaustion); chronic fatigue syndrome; fatiguing physiological factors such as exercise, hypoxia or acceleration; sleep disorders; or the fatiguing effects of infection.

The SAFTE Model has a number of essential features that distinguish it from other attempts to model sleep and fatigue (Table D-1). Together, these features of the model allow it to make very accurate predictions of performance under a variety of work schedules and levels of sleep deprivation.

Table D-1. SAFTE model essential features.

KEY FEATURES	ADVANTAGES
Model is homeostatic. Gradual decreases in sleep debt decrease sleep intensity. Progressive increases in sleep debt produced by extended periods of less than optimal levels of sleep lead to increased sleep intensity.	Predicts the normal decline in sleep intensity during the sleep period. Predicts the normal equilibrium of performance under less than optimal schedules of sleep.
Model delays sleep accumulation at the start of each sleep period.	Predicts the detrimental effects of sleep fragmentation and multiple interruptions in sleep.
Model incorporates a multi-oscillator circadian process.	Predicts the asymmetrical cycle of performance around the clock.
Circadian process and Sleep-Wake Cycle are additive to predict variations in performance.	Predicts the mid-afternoon dip in performance, as well as the more predominant nadir in performance that occurs in the early morning.
Model modulates the intensity of sleep according to the time of day.	Predicts circadian variations in sleep quality. Predicts limits on performance under schedules that arrange daytime sleep.
Model includes a factor to account for the initial lag in performance upon awakening.	Predicts sleep inertia that is proportional to sleep debt.
Model incorporates adjustment to new time zones or shift schedules	Predicts temporary “jet-lag” effects and adjustment to shift work

The Fatigue Avoidance Scheduling Tool (*FAST*™) is based upon the SAFTE model. *FAST*™, developed by NTI, Inc. as an AF SBIR (Air Force, Small Business Innovative Research) product, is a Windows® program that allows planners and schedulers to estimate the average effects of various schedules on human performance. It allows work and sleep data entry in graphic and text formats. A work schedule comprised of three 36-hr missions each separated by 12 hours is shown as red bands on the time line across the bottom of the graphic presentation format in Figure 2. Average performance effectiveness for work periods may be extracted and printed as shown in the table below the figure.



AWAKE	WORK
Start Day - Hr / Duration (Minutes) / Mean Effectiveness	Start Day - Hr / Duration (Minutes) / Mean Effectiveness
0 - 06:00 300 98.97	0 - 20:00 1079 81.14
0 - 14:00 2580 76.42	1 - 14:00 1080 63.97
2 - 17:00 2400 64.78	2 - 20:00 1079 71.23
4 - 18:00 2340 64.58	3 - 14:00 1080 54.51
6 - 19:00 1741 72.23	4 - 20:00 1079 72.00
	5 - 14:00 1080 54.92

Figure 2: Sample FAST^{tm} display. The triangles represent waypoint changes that control the amount of light available at awakening and during various phases of the circadian rhythm. The table shows the mission split into two work intervals, first half and second half.

Sleep periods are shown as blue bands across the time line, below the red bands.

The vertical axis of the diagram represents composite human performance on a number of associated cognitive tasks. The axis is scaled from zero to 100%. The oscillating line in the diagram represents expected group average performance on these tasks as determined by time of day, biological rhythms, time spent awake, and amount of sleep. We would expect the predicted performance of half of the people in a group to fall below this line.

The green area on the chart ends at the time for normal sleep, ~90% effectiveness.

The yellow indicates caution.

The area from the dotted line to the red area represents performance level during the nadir and during a 2nd day without sleep.

The red area represents performance effectiveness after 2 days and a night of sleep deprivation.

The expected level of performance effectiveness is based upon the detailed analysis of data from participants engaged in the performance of cognitive tasks during several sleep deprivation studies conducted by the Army, Air Force and Canadian researchers. The algorithm that creates the predictions has been under development for two decades and represents the most advanced information available at this time.

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(U) Introduction. Based on previous work done at DRDC Toronto, the Aerospace and Undersea Medical Board drafted aeromedical policy to allow short term (max 5 days consecutive) flight surgeon supervised use of certain sleeping medications in aircrew during operations that are known to impact on aircrew sleep. Because of alternating day, off−circadian operations, there was a recent locally initiated change in the use of zopiclone in Camp Mirage aircrew to alternate day use throught the 56−day rotations. DRDC Toronto was asked to evaluate this off−nominal use of zopiclone in CF aircrew. Methods. FAST (Fatigue Avoidance Scheduling Tool) a performance modeling program was used to predict the impact of zopiclone and to compare an alternative duty schedule (3 days of work followed by three days off) against the current schedule (cycles one 1 day of work and 1 day off) across three mission take−off times (0300 hrs, 0700 hrs, and alternating 0700 hrs &0300 hrs). Crew duty data and sleep behaviours (reported to the attending Flight Surgeon) were used as inputs to FAST in order to generate 12 cognitive effectiveness models. Results. The models predict that the current schedule provides better sustained performance than a 3 days on/3 days off schedule, especially for the 0300 hrs take−off missions. The current use of zopiclone to support early circadian pre−mission sleep predicts a 4% to 6% increase in average mission cognitive effectiveness relative to no use of zopiclone. Discussion. These performance models were based on reported sleep behaviours as distinct from actgraphically measured sleep. This modelling effort, although worthwhile in the short term, should be repeated based on actigraph data in order to provide objective sleep bahaviour for re−calculating the performance models.

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(U) Aircrew fatigue; mission schedule; sleeping medications; cognitive effectiveness

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